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# KEWA

NEWSLETTER OF THE LONDON CHAPTER,
ONTARIO ARCHAEOLOGICAL SOCIETY
Grosvenor Lodge, 1017 Western Road, London, ON. N6G 1G5
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LONDON CHAPTER OAS

December, 1994 — 94-8

## MTO INVESTIGATIONS OF THE H.H. MIDDLE WOODLAND SITE, HAMILTON

Phil Woodley

Those of you expecting John MacDonald as our January speaker are in for a surprise...John can't make it! Instead, we have corralled Phil into coming out two months early to present the work that MTO conducted on this very important Middle Woodland occupation at the western end of Lake Ontario. Thanks for saving our bacon, Phil! Meeting time is January 12th at Grosvenor Lodge.

Next Month: February we offer something out of the ordinary and very special. Dr. C. Donnan of UCLA will be discussing the work he has conducted on Moche burial tombs along the north coast of Peru. This presentation is being co-sponsored with The University of Western Ontario, and will be held on campus, on Thursday, February 9th. See next month's issue for further details.

### PLEASE NOTE

1995 MEMBERSHIP FEES ARE NOW DUE, AT THE SAME INFLATION FIGHTER RATE AS LAST YEAR!!!! PLEASE SEND YOUR DUES IN AS SOON AS POSSIBLE. THANKS.

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ANNUAL RATES

Individual........ $15.00
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## EXECUTIVE REPORT

At the Chapter's Christmas Party, the Annual Business Meeting (which went on for a record 2.5 minutes!) saw the 1995 Chapter Executive fully acclaimed. Basically, this year's Executive consists over everyone from last year, in their same positions, with the addition of Christine Nelson as an additional Director on the Executive. That makes the Executive add up to 9 members. Hey, does that mean there is now a London Chapter Executive baseball team? Also, Bev Morrison has volunteered (?) to take over from Peter Timmins as the Chapter's representative on the City of London LACAC (or whatever they'll be calling it after April!). As usual, Neal Ferris, indentured serf, continues on as Newsletter and Occasional Publications Series editor! And, in case you're wondering, Neal swears, on pain of slow torture, to get a move on and have 2-3 manuscripts ready for publication in the 1995 year....assuming we can afford to produce so many volumes in one bang!

Of course, the changing of one's wall calendar, heralding in the 1995 year, also means that it's time again to renew your Chapter membership fees. Once again, the Chapter has voted to keep fees at their current rates (a bargain at twice the price!). Your fees pay for the production of this Newsletter, so please renew soon, so *KEWA* can continue to be brought to you on its (somewhat) regular basis! As usual, people who haven't renewed by the end of March are removed from the mailing list.

## SOCIAL REPORT

For those of you who managed to get out to the Chapter Christmas party during the snow storm of early December, you'll know that the "Favourite Finger Foods" idea was a big hit. Everyone seemed to enjoy themselves, and Neal and 'Nina report that the only thing left behind (besides lots of leftovers) was one small cold virus! Thanks again to Neal and 'Nina for hosting the party, and they say thanks to the Chapter and Pat Weatherhead for the thanks and gifts offered!

Thanks to the good contacts of recent Chapter members Andrew and Christine Nelson, and the cooperation of the Anthropology Department at the University of Western Ontario, we should have a very interesting speaker night lined up for February. More details will appear in next month's issue of *KEWA*, however, we can say that you can expect to see some pretty spectacular archaeology from northern Peru, featuring the kind of stuff one usually sees in the National Geographic, Archaeology, and so on.

## EDITOR'S REPORT

This month we provide *KEWA* readers with a reprinted article, which first appeared in the December 1991 (Volume 5 number 1) issue of *Birdstone*. This article reviews some of the common ecological factors which may have influenced Iroquoian village location and relocation patterns in southern Ontario. Once again we see what the potential benefits good local occupational sequences can have for interpreting the archaeological record. Many thanks to both the Grand River - Waterloo Chapter and the article authors for allowing us to provide it here.

# IROQUOIAN VILLAGE ECOLOGY

Rudy Fecteau, James Molnar, Gary Warrick

## Introduction

In the northern temperate forests of North America, the first farmers practiced slash-and-burn or swidden agriculture. Temperate forest swiddening has been termed pioneer swiddening, utilized in frontier situations (Harris 1972:249). It is characterized by clearance of primary or secondary forest, utilization of garden plots for less than a generation, creation of new plots within an easy walk of the settlement, and finally relocation of settlements when distance to gardens becomes too great or population growth places excessive demands on local forest resources. According to seventeenth-century European observers of Huron communities, village relocation occurred when arable soils and firewood became scarce (Thwaites 1896-1901: 10:275; 11:7; 15:153; Wrong 1939:92-93). The duration of seventeenth-century Iroquoian settlements varied from 8-30 years, values supported by archaeology (Warrick 1988).

Two regularities of Iroquoian settlement pattern which may offer insights into village relocation and ecology include shape and size of agricultural catchments, and distance between contemporaneous and successive village sites. Based on historical vegetation, soil and local topography, Iroquoian villages seem to have possessed semi-circular rather than circular agricultural catchments (Heidenreich 1971:214; Warrick 1990:74; Warrick and Molnar 1986). Also, the distance between contemporaneous and successive villages appears to be 2.0 km +/- 0.6 (n=44 sites). This paper will attempt to explain these regularities in the context of an Iroquoian strategy for maximizing resources of the forest and gardens.

## Village Catchment

Iroquoian archaeologists have used versions of Site Catchment Analysis (Vita Finzi and Higgs 1970) to model village ecology and regional settlement patterns (eg. Bond 1985; Jamieson 1986; MacDonald 1986; Snow 1986; Sykes 1980; Williamson 1985). Most studies have concentrated on the size of agricultural catchment based on formulae developed by Robert Carneiro (1960). Snow (1986) has developed a matrix which examines village population, duration, and size of agricultural catchment, and discovered that a village of less than 200 Iroquoians would never exhaust its agricultural catchment within a reasonable walk of the village. MacDonald's (1986) simulation for the Coleman site in the Regional Municipality of Waterloo shows similar results.

Shape of village catchment has not received a great deal of study. Jamieson (1986) determined that travel distance (i.e. time taken to traverse terrain) as opposed to linear distance probably leads to more realistic dimensions for the catchment of an Iroquoian village. The Slack-Caswell site in the Regional Municipality of Haldimand-Norfolk possessed an oval catchment of 900 m upstream, 500 m downstream and 400 m in width. As early as 1971, Conrad Heidenreich noted that the agricultural catchments of major historic Huron villages, such as Ossossane, Cahiague,

and Teanaustaye, were semi-circular, based on local soils, drainage, and topography. Subsequent studies have confirmed that Iroquoian villages are often situated at the edge of their agricultural catchments. Limits of cornfields, as inferred from distribution of historic pine stands and easily worked loam or sandy loam soils, have been defined for two clusters of sites near Barrie and Pickering (Bowman 1979; Poulton 1979; Warrick 1990:74; Warrick and Molnar 1986; Williamson 1983). Factoring in sequential village moves produces a clear picture of villages situated at the edge of their agricultural fields (Figure 1), not in the centre as implied by formal catchment analysis (Vita Finzi and Higgs 1970).

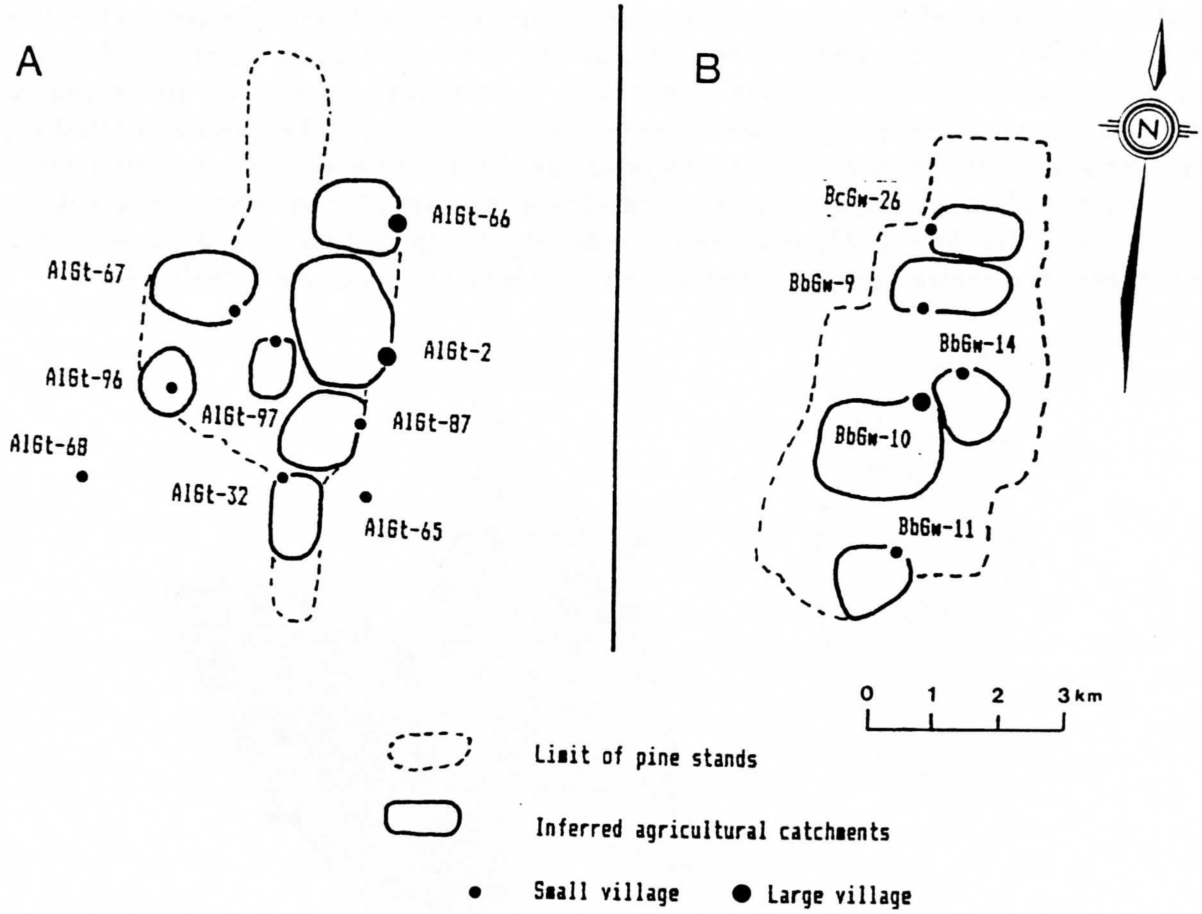


**Figure 1:** Inferred Cornfields Around Iroquoian Village Sites in Pickering (A) and south of Barrie (B).

Actual size of village catchments can be inferred based on the distance between contemporaneous or sequentially occupied sites. A total of 70 intersite distances were compiled ranging from A.D. 900 - 1650 from both southwestern and south-central Ontario. Excluding obvious cases of a village community fissioning into two groups (where social concerns may have been more critical than pure ecological concerns for village location), there is a remarkable consistency, irrespective of site size, in intersite distance, measured as a straight-line distance rather than travel time. Using a sample of 44 sites, intersite distance averaged 2.0 km with a remarkably tight standard deviation of only 0.6 km or 600 metres. This implies two possible patterns of village relocation relative to agricultural fields: (1) establishment of a new village at the outer edge of the old village's semi-circular catchment; or (2) establishment of a new village well beyond the furthest fields of the old village's catchment. The latter strategy makes the most sense ecologically (Figure 2).

### Semi-Circular Catchment and Relocation Strategy

What strategy was behind a semi-circular agricultural catchment and relocation pattern that created a buffer zone of uncleared forest between the outermost edge of old cornfields and the new village site? Why did Iroquoian people wish to be equally close to the forest and their cornfields? In part these questions are answered by considering that the forest and forest edge contained a set of resources essential to Iroquoian life. Uncut forest offered a constant supply of building materials, firewood, nuts, and medicinal herbs and plants. Forest edges offered wild fruit in abundance (Monckton 1992) and a local supply of game. In contrast, once a garden plot had been cleared and choice firewood collected, it would have provided corn - that's all.

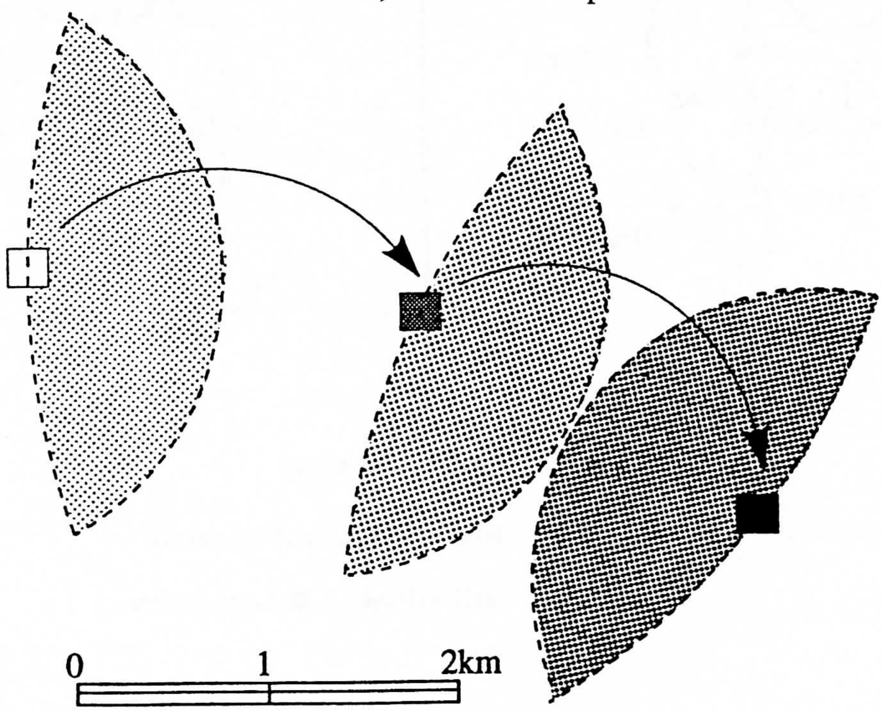


**Figure 2:** Iroquoian Village Relocation. Based on 2 km inter-site distance and non-overlapping and semi-circular agricultural catchments.

Prior to the 14th century A.D., Ontario Iroquoians possessed a settlement-subsistence strategy very similar to their Middle Woodland ancestors. Fish, deer, small game, nuts and fruit would have been very important to have close at hand. Corn was only a minor food source in Early Iroquoian times (Williamson 1985). Thus, it is suggested that distance to forest and distance to cornfields were given equal weight by prehistoric Iroquoians. If this was the case, a semi-circular arrangement of cornfields would have minimized travel-time between isolated garden plots (Figure 3).

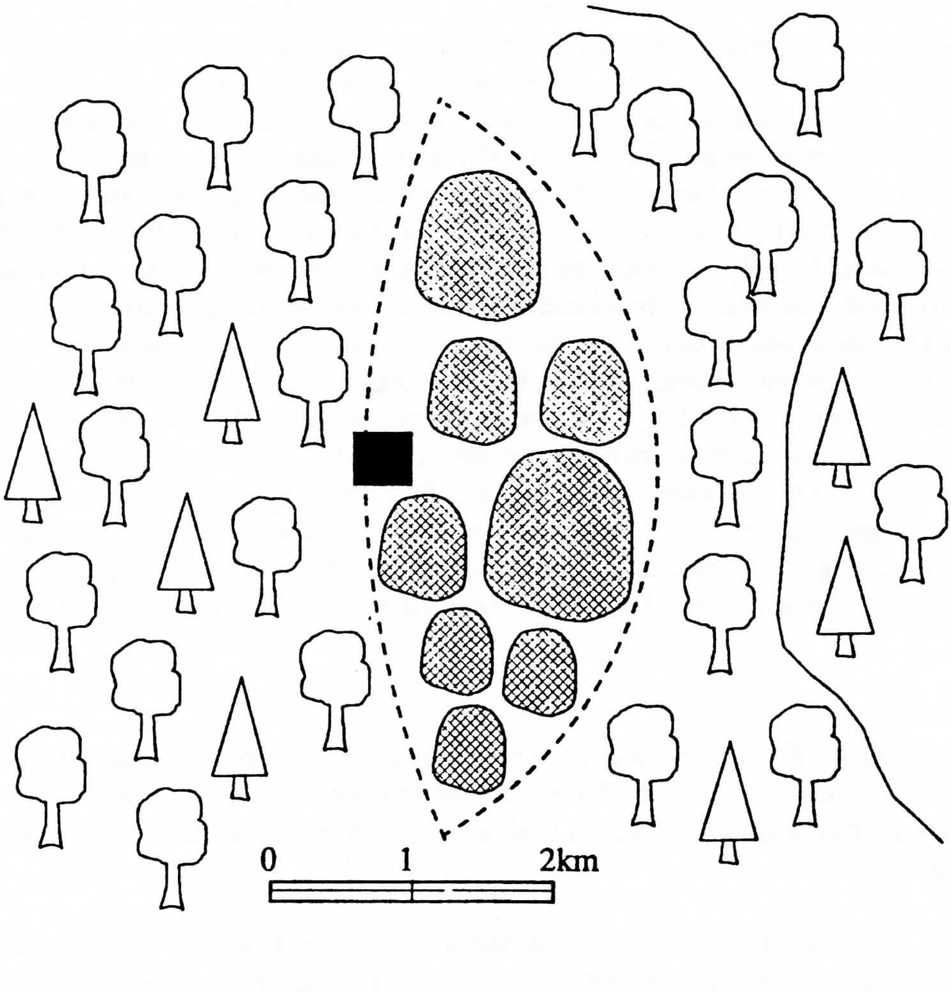


**Figure 3:** Hypothetical Agricultural Catchment Around an Iroquoian Village.

## Iroquoian Village Ecology

The reasons Iroquoians gave to 17th century European observers for why villages were shifted periodically included exhaustion of local soils and depletion of firewood (Thwaites 1896-1901, 10:275; 19:133; Wrong 1939). Additional factors would include physical deterioration of the village and scarcity of building materials, crop infestation, pests, and accumulation of refuse (Starna et al. 1984; Tooker 1984:115; Warrick 1988). Turning this list around, critical resources to an Iroquoian community were corn, firewood, building materials, and country foods (collected nuts and plants, fish, and game). Of these, which were the most important to have close at hand, within a reasonable walk of the village?

### Pre-Industrial Distance

Where societies lack beasts of burden or mechanized transport, people attempt to minimize travel time from settlement to critical resources. Average maximum travel distances for preindustrial agricultural villagers from settlement to gardens is about a 20-30 minute walk unburdened or an hour's walk burdened with a heavy load - about 1.5 kilometres (Chisholm 1968; Conklin 1957; Jarman et al. 1983:30-31). Often the distance to gardens is 0.3 - 1.2 km (a ten-minute walk). Adequate distance really boils down to energy gain for energy expenditure ratios: agriculturalists tend not to tolerate ratios lower than 10:1 (eg. Ellen 1982; Rappaport 1968). The same would apply not only to agricultural activity but also to the gathering and transport of firewood. Obviously, thresholds of travel time would be culturally-specific but generally would not be expected to exceed the energy ratio cited earlier. Based on archaeological data, a two kilometre distance appears to have been the upper limit for Iroquoian travel time with a load of corn, firewood, or building supplies. Allowing for intersite distances being equal to twice the radius of the village catchment, the upper limit for reasonable travel distances would have been 1.0 - 1.3 km. On the other hand, game and fish can be procured at some distance from an agricultural village because it can be processed near the collection site and the weight reduced substantially by drying and discard of unnecessary animal parts (i.e. schlepping). In the seventeenth century, for example, deer were obtained tens of kilometres away from Huron villages.

### Corn

Corn or Northern Flint maize was grown by prehistoric Iroquoians. It is characterized by cobs that were 10 - 27 cm long with 8-10 rows of crescent-shaped kernels. Maize grows best on deep, well-drained fertile loam soils that are friable and moisture retentive (Hartmann et al. 1981; Morris et al. 1981:170).

As noted earlier, Iroquoians practiced upland swidden agriculture. Gardens were cleared from the forest by cutting smaller trees and girdling larger ones. Vegetation was collected and burned and the ashes were incorporated into low mounds of earth upon which the corn was planted. These cornhills had an approximate density of 5000 per hectare (Heidenreich 1974). Yields have been estimated at 910 - 1820 kg/ha (15-30 bushels per acre) and declined steadily in yields after the first year's planting (Fenton 1945; Heidenreich 1971:189-195, 1974; Sykes 1980). Abandonment of fields in loam soils occurred about 10 years after clearance due to reduced fertility and corn

yields (Heidenreich 1971). Following Snow's (1986) model of Iroquoian catchment size, based on a 1700 kg/ha and 230 kg of corn/person/year formula, a new village would require 1400 square metres of land per person in the first year. Given a village of 100 people and assuming one third of the land in a village's catchment was uncultivable, 21 hectares would constitute the agricultural catchment in the first year, 47 at year 10, 87 at year 20, 125 hectares at year 30, and 200 hectares at year 50. If the agricultural catchment was semi-circular rather than circular, the distance to outermost fields after 20 years would be 740 metres and after 50 years would be 1.1 kilometres.

Firewood

An Iroquoian village community would have consumed relatively large quantities of firewood on an annual basis. For the 17th century Huron, women gathered the annual supply of firewood in a few days in early spring, presumably collecting deadfall from the forest floor. Dry wood was selected and probably only branches were used because prehistoric Iroquoians lacked the technology for cutting up fallen tree trunks. Archaeobotanical data indicate that hardwoods were the preferred firewood because of high heat output and less smoke and spark than conifer woods (Fecteau 1985; Monckton 1992). Firewood demands would have been constant for cooking and enormous in the winter for heating longhouses. Experimental data indicate that 0.17 cords of hardwood fuel were needed in a day to keep a small, low-ceilinged five-hearth longhouse comfortably warm during -15° C outside temperatures (Fecteau 1979; see also Twitchell 1977). Thus, each hearth in an Iroquoian longhouse would require 0.04 cords per day for heating. Cooking and reheating a pot of corn soup would consume an estimated .003 cords per day. Presumably one pot of soup per day per family was prepared. For a village of 100 people, and allowing for fires burning down to embers every night in winter and having to be restoked in the early morning, total annual demand for firewood would have been approximately 120 cords.[1]

According to forestry data (S. Moncton, personal communication 1991), a typical hectare of maple-beech forest would contain at least 20 cords of combustible deadfall and would produce this amount each year. Since Iroquoian technology was incapable of cutting tree trunks, branches probably constituted the main source of firewood (Monckton 1992). Given estimated firewood demands, six hectares of forest would have met the demands of a small Iroquoian village without having to venture farther than 200 metres from the village gates.

Building Supplies

Cedar, white pine, and elm were the preferred building materials of Iroquoians because of their high durability. Saplings and bark are not easily transported over large distances, and Iroquoian villages were probably situated so as to minimize the distance between stands of even-aged saplings and the village. Cedar swamps and secondary forests would have provided poles of optimum size for longhouse and palisade construction. Abandoned village sites and fields that had regenerated to forest would have been particularly good sources of saplings. However,

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[1] A cord of wood is 128 cubic feet, as arranged in a pile 8' long, 4' wide, and 4' high.

it takes approximately 50 - 100 years for clearings in a maple-beech forest to be recolonized and 60-160 years for cedar stands to be replenished with trees suitable for village construction (i.e. 6 metres tall and 10 cm thick at the base). This might explain why there are only 8 cases of overlapped villages in Huronia - each pair is a 17th and 15th century site, separated in time by about 150 years.

A brand new 0.4 ha village of four 20 m longhouses would require approximately 1500 poles. However, structural repairs were likely a constant chore for Iroquoian villagers. If longhouse poles were mostly cedar, post deterioration would demand the addition of approximately 800 poles by the 25th year of occupation (Warrick 1988). Cedar swamps contain about 60% cedar, amounting to 5000-12,500 trees per ha. Of these, at least 20% would be suitable for Iroquoian village construction. Consequently, at most only two hectares of cedar stand would need to be harvested to maintain a small village of 100 people for 25 years. Assuming stands average about 100 metres in width, Iroquoian builders would have had to walk no more than 100 metres to obtain construction materials for a 0.4 ha village.

In summary, an Iroquoian village of 100 people occupying the same location for 20 years could have obtained its building supplies within a 100 metre walk, its firewood within a 200 metre walk and the maximum distance to outermost cornfields would have been 750 metres, assuming a semi-circular agricultural catchment. But does this model fit real prehistoric situations?

**Early Iroquoian Occupation of Burlington**

In the early 1980s, the Ontario Ministry of Transportation conducted an archaeological survey of the proposed right of way for an extension of Highway 403 in Burlington. Three Early Iroquoian village sites were found in a tight cluster about 2 km east of the Niagara Escarpment and 7.5 km north of Lake Ontario. From east to west the sites are: Five Acre Field (AiGw-100), Ireland (AiGx-39), and Tara (AiGw-124) (see Figure 4). Surface collections and test excavations were carried out from 1980-1983. In the summer and fall of 1990, salvage excavation of the Tara and Ireland sites was completed (see also Bursey 1994).

Five Acre Field - This site occupies 1.1 ha of a low ridge 50 m from a small stream. In 1976, Arthur Roberts carried out test excavations and obtained an artifact sample from the site, along with a radiocarbon date of A.D. 1222 ± 100 years (WAT-11; Roberts 1976).

Ireland - This village extended over 0.35 ha of a low ridge 75 m from an intermittent stream. Excavations revealed 5 longhouses averaging 18 m in length surrounded by a single row palisade. Two houses are superimposed, giving a contemporaneous hearth count of 10. Ceramic attributes, such as degree of collar development, percent of horizontal motifs, lip decoration, and neck decoration all indicate a late 12th century occupation (see also Bursey 1994).

Tara - This site, situated on a low ridge about 90 metres from a small stream, contained two village occupations - one to the east and one to the west. The east village, enclosed by a doubled

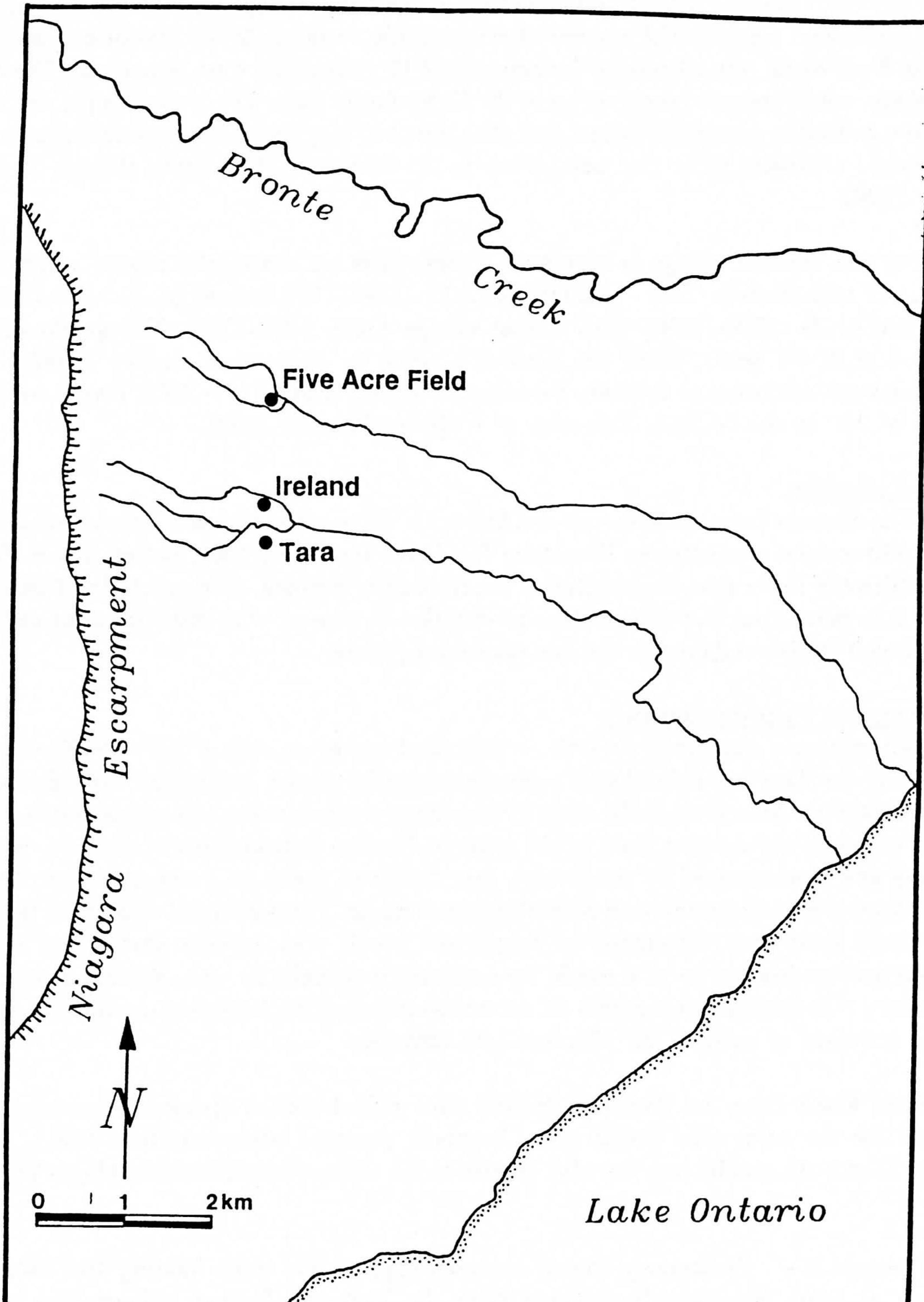


**Figure 4:** Location of Five Acre Field, Ireland and Tara Sites, Burlington.

row of palisade, covered 0.4 ha and contained at least three longhouses. Deep ploughing and erosion eradicated a substantial number of post moulds, resulting in the loss of house walls and palisade. Four burial pits containing the remains of 12 individuals were uncovered. The ceramic assemblage, albeit meagre, suggests an early 12th century date. The west village, enclosed by multi-row palisades, contained the remains of at least two longhouses and covered an area of 0.25 ha. Ceramic attributes place this occupation in the mid-late 13th century (Figure 5; see also Bursey 1994).

Assuming that the four village occupations of these sites are historically related, a hypothetical sequence of relocation is: Tara - east village (A.D. 1150-1170); Ireland (A.D. 1170-1200); Five Acre Field (A.D. 1200-1230); Tara - west village (A.D. 1230-1260). Village durations are estimated at 20-30 years, based on Warrick's work on house post density (1988). Village populations are estimated as follows: Tara-east (n = 160), Ireland (n = 100), Five Acre Field (2 villages of 200 or one of 500), Tara-west (n = 80; see Warrick 1990).

Village Relocation

The distance between Tara-east and Ireland is 430 metres; between Ireland and Five Acre Field: 1300 metres; and between Five Acre Field and Tara-west: 1500 metres. These distances are considerably lower than the standard 2 km relocation distance, particularly for Tara-east and Ireland. It is postulated that village size and duration in concert with distribution of arable land are the major factors responsible for this relocation pattern.

Early Iroquoian Paleo-environment

Vegetation - According to 19th century land survey records (Finlay 1978), the forests surrounding the Tara and Ireland sites were dominated by maple, beech, elm and ash; the forest cover around Five Acre Field in the early 19th century was predominantly maple,beech, pine and oak. Presumably, some cedar grew in the relict and active watercourses in the area, which are low-lying and characterized by Jeddo clay. Ian Campbell (personal communication 1991) has characterized the forests in this part of Burlington as mesic. The primordial or original prehistoric forest would have been dominated by maple and beech, with smaller amounts of elm, ash, ironwood and nut-bearing trees. It would have contained virtually no pine. The implication is that 19th century pine stands in this region do not necessarily indicate Iroquoian cornfields, especially for sites occupied as early as the 12th and 13th centuries.

Carbonized wood from the Tara and Ireland sites reflect similar species frequencies to that predicted for the primordial forest (Ian Campbell, personal communication 1991). Nutshell fragments from oak and hickory are also present in the archaeobotanical assemblages from these sites.

Animal resources - Preliminary faunal analyses suggest that most hunting and fishing was occurring at some considerable distance from the Tara and Ireland villages, but within a reasonable range for hunting and fishing camps from the main village settlement (Jim MacLean, personal communication 1991).

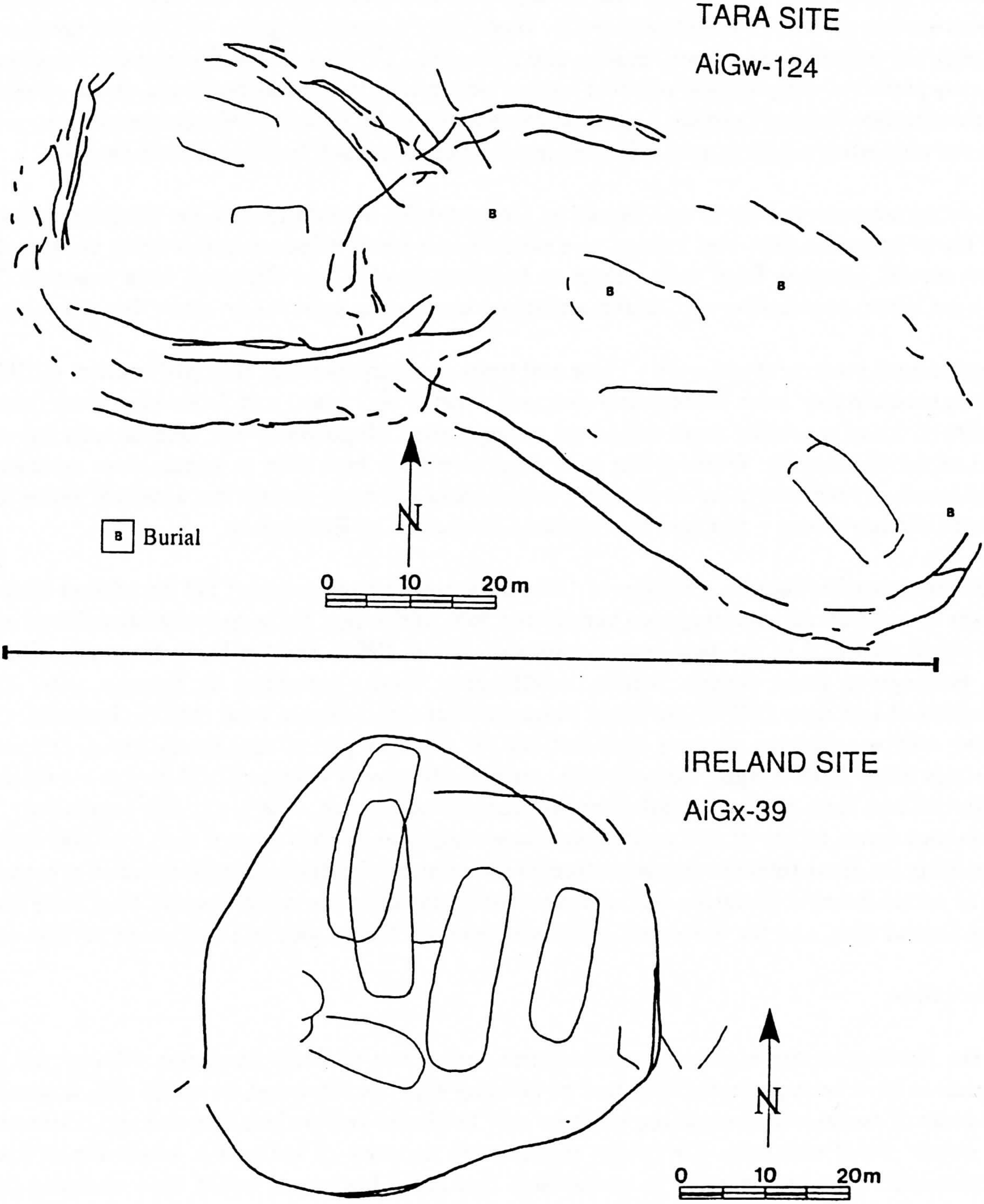


**Figure 5:** Village Plans for the Tara and Ireland Sites.

Indeed, special-purpose hunting and fishing camps are documented for Early Iroquoians in southwestern Ontario (Williamson 1985). Obviously, distance to game or fish did not have a significant influence on village location and relocation. The base of the Escarpment would have been a preferred deer-hunting area and fishing would have been most profitable on the shores of Lake Ontario. Judging from the lack of faunal remains in the Tara and Ireland assemblages, much of the processing of game and fish must have occurred at such special-purpose camps.

Building supplies and firewood - Based on forest species reconstructions, the Burlington cluster of Early Iroquoian sites was located in a maple-beech forest adjacent to low-lying cedar and/or elm stands. Distance from each village to building supplies and firewood were less than 200 metres, given populations of 120 and settlement occupation spans of no more than 30 years.

Agricultural catchment and soils - Three soil types occur in the study area (Gillespie et al 1971): Chinguacousy clay loam (imperfectly drained), Oneida clay loam, and Jeddo clay loam (poorly drained). Land capability maps assign a 1 rating to the Chinguacousy and Oneida soils but only a 3 to the Jeddo soils. While Jeddo soils would not have been able to sustain corn agriculture prehistorically without being artificially-drained., area soil maps reveals that access to arable land would not have been a problem for the Early Iroquoians of Burlington.

Reiterating earlier figures, a village of 100 people would have required 125 ha of land after 30 years of occupation, assuming corn constituted 50% of the diet; fields had to be abandoned after 10 years; and 33% of the land was uncultivable (Snow 1986). For the Early Iroquoian villages in Burlington, these figures require modification. First, according to isotopic data, corn constituted less than 25% of the Early Iroquoian diet (eg. Schwarz et al. 1985). Secondly, clay loam soils would have retained their fertility for a longer period than sandy loams or loams, perhaps 50 to 100% longer. Consequently, an Early Iroquoian village of 100 people would have required less than 50 ha of land after 30 years of occupation. For a circular catchment, this translates into a radius of 400 metres, and for a semi-circular catchment a radius of 560 metres. Applying the latter figure to the reconstructed site sequence in Burlington results in an acceptable fit to actual intersite distances and reconstructed catchments: the catchments of Five Acre Field and Ireland abut, and the Tara-west catchment overlaps the 60 year old catchment of Tara-east.

**Discussion**

If the Burlington site cluster is representative, relocation of Early Iroquoian villages did not appear to have been prompted by a lack of building supplies, firewood, or arable soil. Even after 30 years of continuous occupation, villagers only needed to venture less than one half a kilometre to obtain wood and corn. Given the regenerative capacity of soils in a maple-beech forest (replenished after 60 years), it is conceivable that Early Iroquoians could have occupied their villages on a near-permanent basis (Snow 1986). If this is the case, why did they relocate?

We believe there were multiple causes. First, pests both in the cornfield and village would have been difficult to mitigate (Starna et al. 1984). Unfortunately, we lack empirical values to determine when pests would have become an intolerable problem. Nevertheless, pests and vermin

would have posed a serious limitation to long-term occupations of a village site. Physical deterioration of the village is another factor that would have promoted village removal. As houses became more and more dilapidated, repairs likely would have become an almost daily chore. After 30 years, a house of cedar would literally be falling to pieces, not to mention the increased danger of destruction by fire as the house became more and more weather-beaten and dried out. Also, soot build-up on the roof would have increased the risk of fire over time.

Another set of factors is settlement sanitation. Refuse build-up and risk of parasitic and bacterial infection from human and animal waste within the village compound might have promoted village relocation. The gradual accumulation of village debris or general pollution of habitable space might eventually have forced people to pick up and start the whole process over.

Finally, Snow (1986) has suggested that after 20-30 years, the social fabric of the village may no longer have fit its physical space. The creation of new families and a new generation every 20- 25 years may have contributed to village movement every 25 years or so.

This paper has attempted to explore empirically some regularities in Iroquoian settlement patterns - pattern of village catchment and intersite distance. Ecological factors may account partially for the semi-circular catchment (maximization of forest products [nuts, firewood, medicinal plants, game] and minimization of distance to cornfields) but, except in the large 17th century Huron villages, distance to critical resources and food supply does not appear to have been the cause for why villages moved about 2 km every 15-30 years. Thus the puzzle remains.

## Acknowledgements

We would like to thank the Ontario Ministry of Transportation for providing funding for the excavation and preliminary analysis of the Tara and Ireland sites. This paper was presented at the 24th Annual Meeting of the Canadian Archaeological Association, St. John's, Newfoundland (May 8-11, 1991). MTO funded Gary Warrick to attend the CAA and present this paper.

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